A PROTOTYPE OF REAL-TIME RADIO FREQUENCY MONITORING ON IOT DEVICE

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PROJEK YANG DIKEMUKAKAN UNTUK MEMENUHI SEBAHAGIAN
DARIPADA SYARAT UNTUK MEMPEROLEHI IJAZAH
SARJANA KESELAMATAN SIBER

FAKULTI TEKNOLOGI DAN SAINS MAKLUMAT
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2025

DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries, which have been duly acknowledged.

I acknowledge the use of ChatGPT and https://chatgpt.com/ to generate

Prompt: I entered the following prompt “Create an example of a subheading title for implementation of a real-time monitoring interface”.

Use: I used the selected output, which is the subheading, to create the subtopics 3.6.1, 3.6.2, and 3.6.3 of 3.6 “Integration of Remote Real-Time Monitoring” which are in chapter 3. The topic's internal content is my own research and works.

07 February 2025

MEGAT MUHAMMAD RIDZUAN BIN MEGAT KHAIRULAZHAR
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ABSTRAK

Dalam mengikuti arus pemodenan, peperiksaan adalah satu ukuran untuk menentukan tahap pemahaman pelajar atau individu yang diuji. Peperiksaan yang mempunyai integriti adalah peperiksaan yang bebas daripada tiruan atau penipuan. Bagi memastikan peperiksaan mempunyai integriti yang tinggi, kawalan dan pengawasan oleh pengawas peperiksaan adalah sangat penting. Ini kerana perolehan peranti elektronik yang boleh membantu calon peperiksaan menipu adalah terlalu mudah dibawa dan disembunyikan di dalam dewan peperiksaan. Namun, peranti elektronik moden mempunyai satu persamaan, iaitu ia akan mengeluarkan gelombang radio dalam julat frekuensi yang sama. Kajian ini bertujuan untuk membangunkan alat pengesan frekuensi radio berasaskan Internet of Things (IoT) yang mampu mengesan peralatan elektronik yang memancarkan gelombang radio dan memantau peranti tersebut secara jarak jauh secara masa nyata. Kajian mendapati bahawa alat pengesan frekuensi yang tersedia di pasaran kurang sesuai untuk kegunaan pengawas peperiksaan. Ini kerana alat pengesan yang terdapat di pasaran mempunyai julat pengesanan yang luas, dan ia juga mengeluarkan bunyi bising yang boleh mengganggu tumpuan dan keselesaan calon peperiksaan lain. Keselesaan dan tumpuan semasa menjalani peperiksaan juga merupakan antara faktor yang menyumbang kepada integriti peperiksaan. Peranti yang boleh mengesan peralatan elektronik dengan julat pengesanan yang lebih rendah akan memudahkan pengawas peperiksaan mengesan peranti elektronik dengan lebih tepat. Peranti yang boleh dipantau secara jarak jauh juga akan membantu memastikan tumpuan dan keselesaan calon peperiksaan tidak terganggu. Secara keseluruhannya, alat pengesan frekuensi radio dengan pemantauan masa nyata ini dapat membantu pengawas peperiksaan mengawal calon daripada meniru dan menyalin jawapan menggunakan peranti elektronik yang dibawa masuk ke dalam dewan peperiksaan tanpa kebenaran, seterusnya mengekalkan integriti peperiksaan.

ABSTRACT

In following this trend of modernization, the examination is a measuring line to determine the understanding of a student or individual being tested. An exam with integrity means an exam that does not have any imitation or cheating. To ensure that an examination has high integrity, control, and supervision by the exam supervisor are important. This is because acquiring an electronic device that can help exam candidates cheat is too easy to carry and hide in the exam hall. However, a modern electronic device has one thing in common that is, it will emit radio waves in the same frequency range. This study aims to develop an Internet of Things (IoT) radio frequency detection device capable of detecting electronic equipment that emits radio waves and monitors them remotely on a real-time basis to function. The study found that the frequency detection devices available in the market are less suitable for the use of examination supervisors. This is because the detectors available in the market have a wide range, and they will also emit noise that will interfere with the concentration and comfort of other exam candidates. Comfort and concentration while performing the exam are also some of the variables that contribute to the integrity of an exam. A device that can detect an electronic device with a lower detection range, will make it easier for the exam invigilator to detect the electronic device more accurately. A device that can be monitored remotely, will aid in not disturbing the concentration and comfort of exam candidates. Overall, this radio frequency detection device with real-time monitoring can help exam invigilators control candidates from imitating and copying answers from electronic devices brought into the exam hall without permission, thus maintaining the integrity of the exam.

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3G	Third generation of cellular technology
4G	Fourth generation of cellular technology
5G	Fifth generation of cellular technology
ABAC	Attribute Based Access
ADC	Analogue Detection Circuit
API	Application Programming Interface
CDM	Code Division Multiplexing
CDMA	Code Division Multiplexing Access
CRFS	Cambridge Radio Frequency Systems
GHz	Giga Hertz
GPIO	Input Output
GND	Ground
GSM	Global System for Mobile Communication
HTTP	Hyper Text Transmission Protocol
HTTPS	Hyper Text Transmission Protocol Secured
IDE	Integrated Development Environment
IF	Intermediate Frequency
IoT	Internet of Things
LED	Light Emitting Diode
MHz	Mega Hertz
NTP	Network Time Protocol
PBFT	Practical Byzantine Fault Tolerance
PHP	Hypertext Pre-processor
PoS	Proof of Stake
PoW	Proof of Work

RBAC	Role Based Access
RF	Radio Frequency
RFID	Radio Frequency Identification
RFSA	Radio Frequency Spectrum Analyser
RTC	Real Time Clock
SQL	Structured Query Language
SSID	Service Set Identifier
UKM	Universiti Kebangsaan Malaysia
URL	Uniform Resource Locator
Wi-Fi	Wireless Fidelity
WRIST	Wideband Real-Time RF Identification System
WSN	Wireless Sensor Networks

CHAPTER I

INTRODUCTION

1.1 RESEARCH BACKGROUND

Maintaining the integrity of exams is essential to equitable evaluation and merit recognition in academic contexts. Technological developments have presented opportunities and obstacles, especially concerning upholding the confidentiality of testing environments. This thesis research explores the creation and use of Radio Frequency (RF) Detection Devices integrated with real-time monitoring as a preventative tool to strengthen examination invigilation, in response to the changing nature of academic dishonesty.

Furthermore, academic dishonesty is becoming a bigger problem for educational institutions across the globe. It can take many forms, from conventional cheating techniques to highly technical interventions. Conventional monitoring methods are not always sufficient to counter the covert strategies that the deceitful candidates use. Strong, creative methods to strengthen examination integrity are becoming more and more necessary.

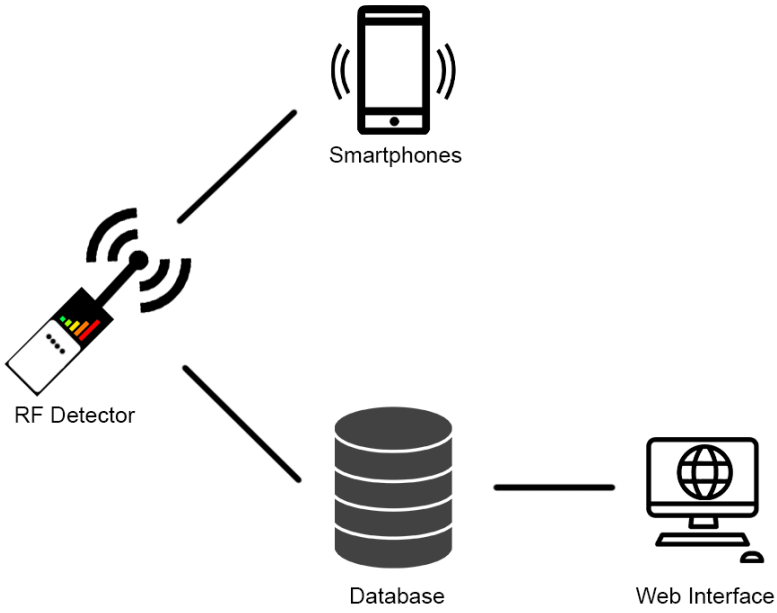

Figure 1.1 Design of the RF detection system integrated with real-time monitoring

Figure 1.1 shows this research project aims to explore and implement an RF detection device with real-time monitoring as a pilot tool in the examination invigilator's arsenal. The device promises a focused strategy to detect unauthorized electronic devices in the exam hall by utilizing advancements in radio frequency technology. RF detection device provides real-time identification and mitigation of potential fraud mechanisms without interfering with the testing process by functioning nearby while the website will act as a monitoring platform and a database to store the device information, the data that is stored in the database then can be viewed by a web interface to determine the location of the devices detected devices.

To continue, the format of this thesis starts with a thorough analysis of the state of academic dishonesty today and the strategies used for examination supervision. Additionally, the study will look at the theoretical foundations of radio frequency detection technologies. Chapter three of this thesis section will describe the experimental design and implementation plan before going into great detail about the analysis of the results. The research's outcomes will clarify the strength and potential applications of RF detection devices in preserving the integrity of the test.

Ultimately, the RF detection device's effective implementation could represent a paradigm shift in the fight against academic dishonesty by providing flexible and scalable ways to improve the integrity of examinations such as implementing real-time monitoring in its development. This technology not only increases the validity of assessments by improving the skills of proctors, but it also promotes an academic atmosphere that values integrity and equity.

In summary, employing a real-time radio frequency detection on IoT device offers a viable means of reinforcing the examination supervision procedure, maintaining the validity of academic evaluation, and preserving the worth of educational credentials.

1.2 PROBLEM STATEMENT

Examination security has become a pressing concern in educational institutions worldwide, with the rise of sophisticated methods of cheating and impersonation. Modern technology, particularly the widespread use of electronic devices such as smartphones has amplified this issue. This devices, when misused in exam halls, undermine academic integrity and fairness. The challenge of preventing such activities requires innovative solutions that can detect these electronic gadgets without disrupting the examination process. This research aims to address several key challenges in overcoming the problem of cheating in examination halls through the use of advanced detection devices.

Developing efficient strategies to combat electronic device-assisted impersonation and cheating is one of the main issues. During tests, students are using their smartphones more and more to interact with outside sources or access the internet. The problem is made more complicated by the fact that smartwatches and wireless earbuds can avoid standard invigilation procedures and are smaller and easier to hide. Technology-assisted cheating is on the rise, endangering not only the reliability of exam results but also the educational process by giving dishonest pupils an unfair advantage. The solution to this issue necessitates a creative strategy that can identify these devices without having to physically inspect every student, which would disturb the examination environment.

Developing techniques to identify electronic gadgets even when they are concealed or masked by test takers is another crucial component. Traditional invigilation methods frequently depend on visual inspections, which are inadequate for identifying contemporary, small devices that are easily hidden in accessories, apparel, or even on the person. Thus, a device that can reliably and correctly detect these devices in real time, even while they are disguised, is desperately needed. This would deter students from trying to bring illegal electronic devices into the exam room in addition to guaranteeing exam fairness.

Moreover, the solution must be designed in such a way that it does not interfere with the concentration and comfort of the exam candidates. It also need to be able to be operated easily by the invigilator so that the students can be able to focus on their exams without feeling overwhelmed or distracted by the detection system. This means that the device must operate discreetly and without emitting loud noises or other forms of disruption that could affect students' performance. A balance needs to be struck between effective detection and maintaining a peaceful examination environment, ensuring that the integrity of the process is upheld without compromising the comfort of the examinees.

1.3 RESEARCH OBJECTIVES

The objective of this research includes:

1. To develop and evaluate a close-range RF detection system integrated with real-time monitoring technology.
2. To design a user-friendly and non-intrusive RF detection system.

1.4 RESEARCH QUESTIONS

Three main research questions can be deducted in performing this research project which are:

1. What are the key features of the suggested approach?

   The research's recommended approach combines several essential elements to guarantee its efficacy and flexibility. It uses an agile, iterative development methodology that permits constant improvement and adaptability during the investigation. The methodology's key component is the use of close-range radio frequency (RF) detection technology to locate and identify unauthorized electronic devices in exam rooms, such as smartphones, smartwatches, and wireless earbuds. Real-time monitoring technology is integrated to allow live monitoring and storing of detection data in an immutable manner. The design places a strong emphasis on the needs of the user, making sure the detection system is discrete, unobtrusive, and doesn't interfere with students' ability to focus or feel at ease during tests.

2. How is the evaluation of the proposed approach conducted?

   A combination of user feedback, technological testing, and practical implementation is used to assess the suggested solution. First, under controlled conditions, the functionality, accuracy, and dependability of the RF detection devices and wireless monitoring system integration are tested for identifying hidden electrical devices. Performance parameters are evaluated, including reaction speed, false positives, detection range, and monitoring data integrity. The usability testing must be performed to make sure the monitoring system is user-friendly, and intuitive while remaining unobtrusive throughout exams. The system is then deployed in a simulated examination setting to evaluate its effectiveness in a live environment, to provide results. The results are analysed to identify areas for improvement, ensuring the approach meets its objectives of enhancing exam security without disrupting the examination process.

3. What is the environment for simulation and evaluation?

   A controlled examination setting that mimics actual exam settings makes up the environment for simulating and evaluating the suggested approach. This setting consists of a specific room furnished with standard desks and chairs. This test is used to evaluate the RF detection system's capacity to detect and locate electronic gadgets, such as smartphones, smartwatches, and wireless earphones are items that are frequently used for cheating and purposefully hidden on or next to the students. Invigilators using the monitoring system of RF detection devices are also a part of the simulation, they observe the test and communicate with the system in real-time. A log of RF detection incidents is produced by recording and authenticating detection events in the database embedded in the network. This environment allows for testing under realistic conditions, ensuring that the system’s functionality, detection accuracy, ease of use, and impact on the exam process are thoroughly evaluated before real-world deployment.

1.5 RESEARCH SCOPE

The scope of this research is to improve the security of examination environments by creating and testing a system that combines wireless real-time technology and close-range radiofrequency detecting sensors. The study focuses on identifying illicit electronic gadgets like smartwatches, phones, and wireless earbuds that are used to cheat in test rooms. Exam invigilators can quietly monitor test takers without interfering with the exam process by using non-intrusive detecting equipment, which is included in the scope of the research project. The study addresses how real-time monitoring technology can be integrated to safely and impenetrably log identified incidences, guaranteeing the accuracy of the data that is recorded. Key areas of investigation include the technical feasibility of RF detection, user experience for both invigilators and students, and the system's scalability to different examination settings. Concerns around privacy, ethics, and law about the usage of this technology in educational settings are also covered in the research.

1.6 SIGNIFICANT OF THE RESEARCH

This research is significant as it addresses the growing challenge of maintaining academic integrity in an increasingly digital world, where students have access to a wide range of electronic devices that can be used to cheat during exams. By creating a system that combines wireless real-time technology and close-range radio frequency detection, the research offers a novel approach to identifying illegal electronic devices in exam rooms, early studies will focus on smartphones. Exam environments are made more secure and reliable by the suggested approach, which also increases the accuracy and effectiveness of identifying these hidden gadgets. The integration of real-time monitoring ensures that all detection incidents are securely recorded and detected, offering a transparent and tamper-proof method for tracking and verifying exam security violations. This level of security is crucial for upholding academic standards and fairness in educational institutions.

Moreover, the study is valuable since it provides a useful and accessible method that can be applied in a variety of learning environments. The RF detection devices are lightweight and non-intrusive, so invigilators can quickly integrate them into their exam

monitoring procedures without bothering students or interfering with the testing procedure. This research helps to protect the integrity of academic assessments by improving the capacity to identify cheating while preserving a favourable exam atmosphere. In addition, this study also examines the privacy and ethical issues associated with using these technologies, which ensures that the solution is not only practical but also complies with legal and educational requirements. This has wider consequences for institutional policy.

1.7 PROJECT ORGANISATION

For the purpose of providing a thorough knowledge of the development and evaluation of close-range RF detection devices combined with wireless real-time monitoring technology for test security, this research is divided into five main chapters, each of which focuses on a distinct component of the study.

The research issue is introduced in Chapter 1, which provides a background and basis for the study. It discusses the rising problem of exam cheating, which is made possible by contemporary technology like smartwatches, cell-phones, and wireless headphones. The chapter outlines the study's goals, constraints, and scope in addition to defining the research problem and its significance. To solve test security concerns, this section also emphasizes how important it is to integrate wireless real-time monitoring technology with RF detection. This sets the ground for the in-depth investigation that will take place in the upcoming chapters.

A thorough analysis of the body of research on wireless monitoring, exam security protocols, and RF detection methods is given in Chapter 2. It looks at earlier research and suggested remedies to stop exam cheating, assessing the benefits and drawbacks of each. This chapter lays the groundwork for comprehending the state of science and technology today and points out the gaps that the suggested system seeks to solve. The integration of wireless real-time monitoring technology with RF detection in academic contexts raises ethical, privacy, and legal questions that are covered in the literature review.

The research approach is thoroughly explained in Chapter 3. The methodical technique used to design, develop, and execute the real-time monitoring integrated with the RF-detecting device is described in this chapter. It represents the development process, system design, and technology selection, emphasizing the agile technique that leads the research project through its iterative stages. The testing framework, comprising the simulation environment, hardware, and software settings, as well as the methods for gathering data to assess system performance, are also covered in this chapter.

The performance assessment of the created system is the main topic of Chapter 4. It displays the findings from both controlled simulations and actual testing, evaluating how well the RF detection devices find hidden electronic equipment when taking tests. This chapter assesses the wireless real-time monitoring ability to securely log and validate detection data as well. An analysis is conducted on critical performance indicators, including detection accuracy, response time, user experience, and system scalability. The chapter addresses any issues that arose as well as potential areas for system performance enhancement.

As the last chapter, Chapter 5 summarises the research findings and inferences made from the experimental data. It examines the efficacy of the suggested approach in addressing exam cheating and emphasises how it upholds academic integrity. The chapter also discusses the study's shortcomings and makes suggestions for further investigation and system improvements. The final section of this paper addresses the research's wider ramifications for academic institutions as well as the possibility of future technological advancements and applications.

CHAPTER II

LITERATURE REVIEW

2.1 CHAPTER OVERVIEW

A review of the literature functions as a critical synthesis of the body of knowledge relevant to a specified subject or research question. This crucial part of academic writing establishes the foundation for the study by pointing out gaps, discrepancies, and consensus areas in the body of previous research, as well as demonstrating the researcher's expertise in the field. A literature review looks at a variety of sources, such as books, dissertations, peer-reviewed publications, and conference proceedings, to establish the theoretical framework, give context, and support the need for additional research.

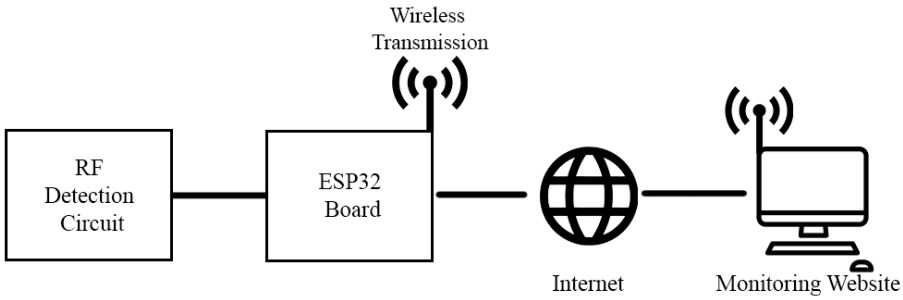

Figure 2.1 Real-time RF Detection Monitoring System

Figure 2.1 shows the rough sketch of the Real-time RF Detection Monitoring System layout. This chapter will depict the current devices that are available for detecting the radio frequency of hardware that can or may be used for the purpose of cheating or unintentionally being brought into the examination hall. Many types of hardware or systems are currently available to use for detecting the RF that is transmitted by an electronic device, this chapter, will discuss the advantages of the RF

detection system and extract their advantages and disadvantages it. This chapter will also explain the current wireless monitoring technology, what technique of wireless monitoring is available, and each of their advantages and disadvantages. This chapter will also study the security features that can be implemented in the monitoring system to maintain the integrity of the logged files from the RF detection circuit that will be develop.

Before ending the chapter, a study on related works are done to provide insights on the current existing technologies that are being used in this field. In the end of this chapter, a verdict will be made on which technology that is compatible to be used for the research project of RF detection devices that will be integrated with the chosen wireless real-time monitoring system.

2.2 RADIO FREQUENCY DETECTION

Research on the existing systems and devices that is used to detect electronic devices is conducted, to keep up with the current technology and standards. This literature review is also carried out to see the existing wireless real-time monitoring systems that can aids to detect any electronic devices that are available in the market today. This research on past and existing literature is carried out to see the gap that exist in the current technology and standards and solve its problem tally to our need.

2.2.1 Radio Frequency Detection Scanners

RF (Radio Frequency) scanners are devices designed to detect the presence of radio frequencies emitted by electronic devices. These scanners are used to identify unauthorized devices such as smartphones, smartwatches, and wireless earphones by scanning for their RF signals within a specified range.

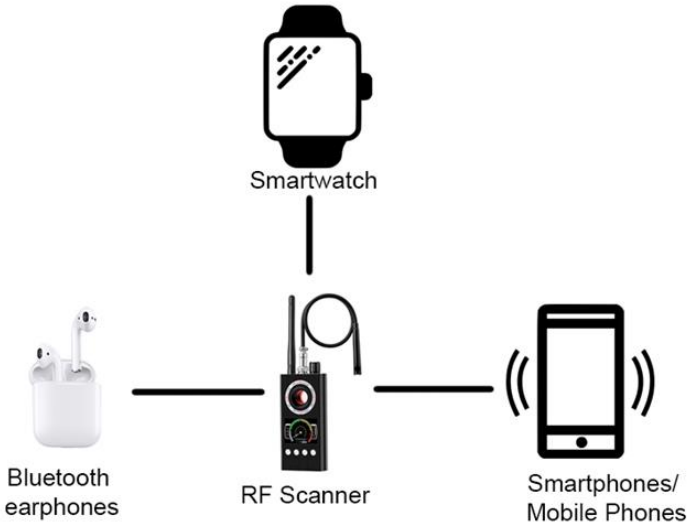

Figure 2.2 RF Scanner and example of devices it can detect.

Figure 2.3 it shows the characteristics of RF Scanners which are RF scanners are capable of detecting a wide range of radio frequencies, including those used by cellular networks (GSM, CDMA, 3G, 4G, and 5G), Wi-Fi, Bluetooth, and other wireless communication protocols. An advanced RF scanners can analyse the detected signals to identify the type of device emitting them based on their frequency, signal strength, and modulation patterns. Next, effective range of RF scanners can vary, typically covering areas from a few meters to several hundred meters, depending on the scanner's power and sensitivity. Moreover, RF scanners can be handheld portable units, fixed installations, or integrated into larger security systems, providing flexibility in deployment.

Radio frequency detection devices consist of interconnecting components that are working together to identify and analyse the RF signal that are emitted by the electronic devices like smartphones, smartwatches and other wireless gadgets. The key components of the RF signal detection devices are shown in Table 2.1.

Table 2.1 RF detection device main components

Component	**Usage**
Antenna	This will be the component that will capture the RF signals that are being used in the environment. The design of the antenna will determine its sensitivity and operating frequency range, which are crucial for detecting the device within specific frequency bands.
Signal detectors	This component will capture the signals into a readable voltage output, a metal-semiconductor diodes are usually being used due to low voltage requirements and minimal charge storage, enabling power detection in high and low range.
Filters	Filters are used to isolate the specific frequency bands and reducing noise and enhancing the detection of the desired specific range of signals.
Amplifiers	This component will be used to boost the weak signal level to a more desired readable levels so that it can be analysed effectively. A high gain amplifier is being used to ensure an accurate detection of low-power radio wave emissions'.
Indicators	Most of the indicators that is being used for RF detection devices are the LEDs

The antenna captures RF signals, which are amplified by the RF amplifier. The band-pass filter ensures only the desired frequencies are processed, and the mixer translates the signal to a lower frequency. The signal detector identifies and quantifies the signal, which is then processed by a microcontroller. The results are displayed or transmitted via the output indicators like an LED.

RF scanners provide a robust and effective solution for examination invigilators to prevent cheating by detecting unauthorized electronic devices. Their necessity and appropriateness for an examination invigilator. RF scanners offer a high level of detection accuracy, identifying a broad spectrum of devices through their RF emissions, making them highly effective in maintaining exam integrity. There are advantages and disadvantages of the RF Scanner:

RF scanners offer several advantages, including the ability to detect a wide range of electronic devices by identifying their radio frequency emissions, even if the devices are hidden or turned off but still emit residual signals. They provide real-time detection and monitoring, enabling invigilators to quickly identify and address unauthorized devices, and their non-intrusive nature ensures they do not interfere with other electronic systems. However, RF scanners also have disadvantages, such as requiring technical expertise to interpret signals accurately and differentiate between authorized and unauthorized devices. In environments with many legitimate RF-emitting devices, distinguishing between these and unauthorized signals can be challenging, potentially leading to false positives. Additionally, high-quality RF scanners can be costly, representing a significant investment for educational institutions.

In conclusion, RF scanners are a powerful tool for examination invigilators, offering comprehensive and non-intrusive detection of unauthorized electronic devices. Their effectiveness in real-time monitoring and broad coverage makes them a valuable asset in maintaining the security and integrity of examinations

2.2.2 Radio Frequency Spectrum Analysers

Radio Frequency Spectrum Analysers (RFSAs) are essential tools for analysing and visualising the spectral composition of signals, providing insights into frequency, amplitude, and signal distribution. These tools are frequently used in electronics, RF engineering, and telecommunications to assess bandwidth, measure signal intensity, and identify interference.

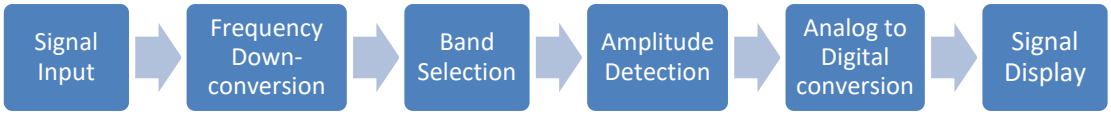

Figure 2.2 RFSA workflow

Figure 2.2 starts the diagram with the RF signal entering the spectrum analyser through an antenna or direct connection, this is from signal input. Then, the frequency down-conversion is done by mixing the input signal with a local oscillator signal to down-convert it to an intermediate frequency (IF). This step reduces the frequency range, focusing on the portion of interest. The filters are then applied to isolate the device to the user's desired frequency range. The band selection process ensures that the analyser measures specific portions of the RF spectrum while rejecting unwanted signals. After the band selection is done, The IF signal is amplified and converted into its amplitude component using detectors. This component reveals how much power the signal has at various frequencies. Then analogue-to-digital conversion is mostly used in modern digital spectrum analysers, the amplitude data is converted to a digital format for further processing and display of the signal.

RFSA devices are widely used in telecommunications, electronics, and RF engineering to measure signal strength, detect interference, and evaluate bandwidth Radio Frequency Spectrum Analysers (RFSAs) offer significant advantages, including accurate frequency domain analysis by measuring and displaying signal amplitudes across a wide frequency range, making them invaluable for diagnostics and system optimization. They are widely used in fields such as wireless communication for troubleshooting RF signals, audio engineering for balancing frequencies, and research